Appendix C White Chuck River Slope Stability Hazard Assessment (Process Documentation)

The evaluation of slope stability within the White Chuck River watershed included the use of six interrelated physical characteristics. Bedrock geology, slope morphology, soil parent material, soil infiltration characteristics, precipitation zones, and previously identified highly unstable soils were all used in the evaluation process. On non-Forest Service lands, Washington State Dept. of Natural Resources digital data layers for soil parent material, infiltration rates, slope morphology, and precipitation zones were used for the model. A GIS (Arc/Info) model was used to integrate the 6 characteristics and assist with interpretations. While it is recognized that slope stability is the result of complex interactions between the physical site characteristics used in this evaluation, an assumption is used that they can be rated individually and evaluated based on the summary of the individual ratings.

1) Geologic units used for the evaluation (Tabor 1993) are briefly described in the attached appendix. The principal characteristics used in assigning a hazard or susceptibility rating were the relative strength or competency of the bedrock. Hazard ratings were assigned as follows:

Geologic Description	Mass Wasting Rating
Landslide Deposits (Ql) Alluvial Fan (Qf) Laharic Deposits (Qlh) Recessional Outwash Deposits (Qvr) Peridotite & Serpentinite (Tkhm)	7 (Highest risk)
Darrington Phylite (Ked) Phyllite (TKwp) Mixed Shuksan Greenshits and Darrington Phyllite (Kem) Slate of Rinkle Ridge (Slate & Phylite) (Krs) Semischist/slate (TKws) Argillite (Tkea) Greenstone (TKhg) Trafton Melange (TKt)	5 (High Risk)
Shuksan Greenshits (Kes) Advance outwash deposits (Qva) Stillaguamish sand member- recessional outwash (Qvrs) Sandstone (Tbs) Younger alluvium (Qyal) Mafic Medavolcanic- graywache, argillite (TKev) Volcanic rocks of White Horse mountain (Tkew) Rhyolite flows and rhyolite ash flow tuff (Tbr) Glacial Till (Qvt) Tonalite (Tst)	3 (Moderate Risk)

Geologic Description	Mass Wasting Rating

Gabbro with diabase dikes (Tkegg)	1 (Low Risk)
Bog deposits (Qb)	
Alpine glacial deposits (Qag)	
Older Alluvium (Qoal)	
Chert (Tkec)	
Marble (Tkem)	
glaciers (gl)	
water (wa)	

2) Slope morphological characteristics (steepness and shape) were also used in the evaluation of slope stability within the White Chuck River watershed. The methodology described in "Slope Morphology Model Derived From Digital Elevation Data" (Shaw & Jackson 1995) was used (with minor variation) for this evaluation. The variables and associated ratings used in the model consist of the following:

% Slope	Slope Rating	Slope Description
0-15	10	Relatively Flat
16-24	20	Low Gradient
25-47	30	Moderate Gradient
48-70	40	High Gradient
>70	50	Extreme Gradient

Slope Shape	Slope Shape Rating
Concave	1
Planar or Flat	2
Convex	3

Joining the slope steepness and slope shape characteristics results in the following potential combinations:

	Slope Steepness				
Slope Shape	0-15%	16-24%	25-47%	48-70%	>70%
Concave	11	21	31	41	51
Planar	12	22	32	42	52
Convex	13	23	33	43	53

Hazard ratings were then assigned to the various combinations of the slope steepness and slope form variables:

High Risk (41, 51, 52)= **9**
Moderate Risk (42, 53)= **5**
Low Risk (11, 12, 13, 21, 22, 23, 31, 32, 33, 43)= **1**

3) Characteristics of soil parent material have the potential of influencing slope stability characteristics. Mass wasting inventories have identified a general tendency for failures to occur more frequently in glacially deposited parent material. Shallow landsliding also occurs in avalanche tracks in association with snow-melt. Soil parent materials within the White Chuck River watershed were grouped and rated as follows:

Parent Material	Mass Wasting Rating
Glaciolacustrine Deposits Interbedded Glaciallacustine Deposits	10 (Highest Risk)
Glacial Drift Glacial Till Glacial Till and Glacial Drift Glacial Till of Granitic origin Residium and Till Residium and Glacial Till Complex	7 (High Risk)
Alluvium Residium Colluvium Residium and Colluvium Colluvium and Till Talus slopes and Boulder deposits	4 (Moderate Risk)
Colluvial boulder deposits Rock outcrop Rock outcrop/Talus slopes/Meadows Rock outcrop/ perpetual snow and ice Organics	1 (Low Risk)

DNR parent material was rated as follows:

Glaciolacustrine deposits Ash and Loess over glaciolacustrine	10 (Highest risk)
Glacial till Glacial outwash Ash over glacial outwash Ash over Breccia Ash over glacial till Ash/Pumice over alluvium	7 (High risk)
Ash & loess over igneous bedrock Clay or fine textured fine alluvium	4 (Moderate risk)
Sandy alluvium Mixed alluvium Peat or decomposed organic matter Cobbly fan deposits Sandy and/or silty alluvium Silty alluvium over sand and gravel	1 (Low risk)

4) The ability of water to infiltrate and move through the soil was assumed to have a significant influence on slope stability characteristics. Soils were grouped and assigned the following ratings:

Soils Hydrologic Group (SRI)	Rating
(D) Very slow infiltration and transmission characteristics	6 (Highest Risk)
(C) Slow infiltration and transmission rates	3 (High Risk)
(B) Moderate infiltration and transmission rates	2 (Moderate Risk)
(A) High infiltration and transmission characteristics	1 (Low Risk)

DNR Percolation Rate	**Rating**
Very slow (< 0.06"/hr.)	6
Slow and moderately slow (0.06 - 0.6"/hr.)	3
Moderate (0.6 - 2.0"/hr.)	2
Moderately Rapid to very rapid (2.0 - 20.0"/hr.)	1
Not applicable	1

5) Precipitation was also used to evaluate slope stability within the North Fork Stillaguamish River watersheds. The type of precipitation events that are typically experienced throughout various areas of the watershed were assumed to have an influence on occurrence and distribution of mass wasting events. The precipitation events that occur within the North Fork Stilly watershed and their associated assigned hazard ratings are as follows:

Precipitation Type	Rating
Rain on Snow Zone	6 (Highest Risk)
Rain Dominated Zone	3 (High Risk)
Snow Dominated Zone	2 (Moderate Risk)
Highland	1 (Low Risk)

6) Highly unstable soils as identified in the Land and Resource Management Plan for the Mt. Baker-Snoqualmie National Forest were also included in the evaluation of slope stability within the White Chuck River watershed analysis area. These soils are referred to as **(S-8)** and are defined as: "those soils whose instability is such that timber harvesting or road building will have a 75% probability of doubling the slide occurrence". The S-8 category was not intended to identify all unstable or "potentially" unstable soils, only the extreme conditions were included. Approximately 1,019 acres of S-8 have been identified within the White Chuck River watershed and all are included within the high potential for mass wasting category.

OVERALL SLOPE STABILITY RATING

A summary rating for each polygon was generated from the additive combination of 5 of the 6 characteristics used for the slope stability evaluation. The S-8 characteristic used in the evaluation did not receive a rating but S-8 polygons were automatically included in the high risk category. Possible summary value ratings ranged from 5 to 38. For example:

Geology Rating	Geomorph Rating	Parent Material Rating	Hydrologic Group Rating	Precipitation Zone Rating	Summary Rating*
1	1	1	1	1	5
3	5	4	2	2	17
5	9	7	3	3	27
7	9	10	6	6	38

* These are not the only possible combination of ratings, but are given here to show how individual ratings are added to give a summary value.

The White Chuck River watershed was stratified into areas of low, moderate, and high categories of mass wasting potential based on the summary rating values. Arc/View was used to plot and evaluate several different scenarios of summary rating breaks. Based on field observations and the best professional judgement of local physical sciences professionals, the following breaks were established:

Summary Rating	**Mass Wasting Potential**
< 16	Low Potential
16 - 22	Moderate Potential
>22	High Potential

The product of this modeling exercise needs to be correlated with existing landslide inventories. The identified high potential areas need to be further investigated during site specific project planning for the NEPA process. Such investigations will be necessary in order to validate model assumptions and conclusions.

RATING

A summary rating for each polygon was generated from the additive combination of 5 of the 6 characteristics used for the slope stability evaluation. The S-8 characteristic used in the evaluation did not receive a rating but S-8 polygons were automatically included in the high risk category. Possible summary value ratings ranged from 5 to 38. For example:

Geology Rating	Geomorph Rating	Parent Material Rating	Hydrologic Group Rating	Precipitation Zone Rating	Summary Rating*
1	1	1	1	1	5
3	5	4	2	2	17
5	9	7	3	3	27
7	9	10	6	6	38

* These are not the only possible combination of ratings, but are given here to show how individual ratings are added to give a summary value.

The XXXXXXXXXXXXX watershed was stratified into areas of low, moderate, and high categories of mass wasting potential based on the summary rating values. Arc/View was used to plot and evaluate several different scenarios of summary rating breaks. Based on field observations and the best professional judgement of local physical sciences professionals, the following breaks were established:

Summary Rating	**Mass Wasting Potential**
< 16	Low Potential
16 - 22	Moderate Potential
>22	High Potential

The product of this modeling exercise needs to be correlated with existing landslide inventories. The identified high potential areas need to be further investigated during site specific project planning for the NEPA process. Such investigations will be necessary in order to validate model assumptions and conclusions.